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A Technical Publication Devoted to the Selection and Use of Lubricants

This Issue

FLEXIBLE COUPLINGS

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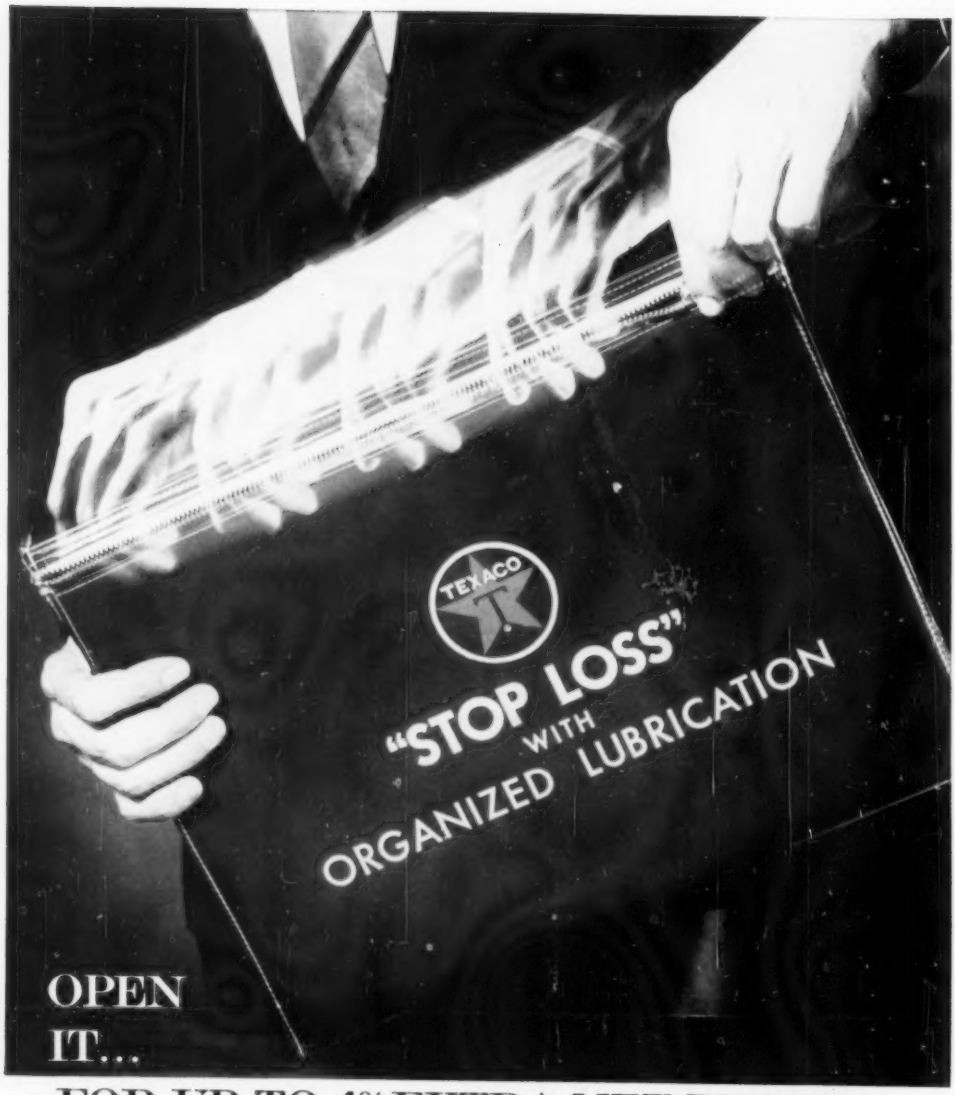

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FLEXIBLE COUPLINGS—I*

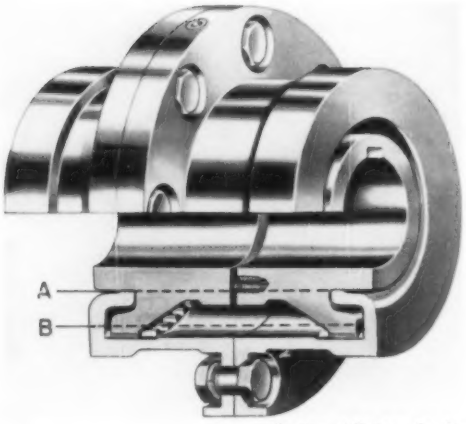
COUPLINGS of some type have long been used to connect shafts which were at least approximately aligned. Speeds and loads in the earliest machines were sufficiently low so that simple rigid sleeve-type couplings could generally be used to accommodate minor shaft misalignment without adversely affecting bearings or other parts of the equipment. However, as speeds and loads increased the destructive effects of shaft misalignment on bearings and other components increased so greatly that it became necessary to develop *flexible* type couplings which would withstand and compensate for shaft misalignment. Although flexible couplings are generally a very small part of the over-all equipment on which they are used, their function of transmitting power is a very important one. In order to assure their efficient operation under widely varying conditions of use on a large variety of machines many factors must be considered during their design, selection and application.

In the most inclusive sense a flexible coupling may be defined as a mechanical device used to connect two shafts where perfect alignment, either lateral or angular, is not attainable initially or not maintainable during operation. In such an all inclusive definition, universal joints and flexible cable drives would also be included. The former can be operated at angular misalignments up to 30°, while the latter has practically unlimited flexibility, but both are suitable for transmitting only relatively light loads.

In more common use in industry is a more restrictive technical definition wherein the flexible coupling is considered a mechanical connection used to transmit torque and power from a driving to a driven shaft of a power driven machine and capable of compensating for relatively small movement between the two shafts due to misalignment. The movement may be either angular, parallel, axial shaft end float, a combination of any two or all three. Generally, flexible couplings are used where misalignment and consequent relative movement between connected shafts are not great enough to require a universal joint. In addition to compensating for relative movement between connected shafts, flexible couplings provide protection against vibration, shock loading and noise. The extent of protection varies somewhat among the different types of flexible couplings, their application, installation, and operating conditions.

The first flexible couplings were intended only to compensate for relative shaft movement and end float caused by errors in initial static alignment. Even when perfect *initial* alignment is attainable through costly design and construction, there is no assurance that it can be *maintained* during operation for any appreciable length of time because of the effects of changing temperature, wear of bearings, deflection of structural support members un-

*In view of the complexity and extent of information on Flexible Couplings, this article is divided between the October and November 1961 issues of this publication.



Courtesy of Koppers Co., Inc.

Figure 1 — General purpose double engagement gear coupling showing functional components and oil levels in standing (A) and running (B) positions.

der load, settling of the machine's foundation, vibration and other factors.

In more recent years due to developments and improvements in flexible coupling design and the desire of manufacturers to extend or expand the useful application of flexible couplings, they are also being used to a considerable extent for applications where greater shaft misalignment either intentional or unknown exists.

The first flexible couplings used extensively on power driven machinery were those containing, as the name implies, a flexing member such as metal springs, laminated pins and disks, rubber, plastic, or fabric impregnated with rubber or plastic. As requirements for greater torque and power transmission continued to increase, it became necessary to design mechanical couplings with rigid components wherein flexibility was derived from relative movement between properly designed rigid parts. Such couplings required lubrication to keep their moving contacting parts as free as possible from friction and wear and thus provide trouble-free operation for extended periods of time.

TYPES OF COUPLINGS

Since there are over 100 basic types of flexible couplings manufactured in the United States alone[1] and a number of foreign manufacture are also in use in this country, this article will not attempt to cover all types. However it contains and supersedes a previous issue[2] of similar subject.

[1] In this issue superior figures refer to correspondingly numbered items in its bibliography.

Flexible couplings can be grouped into the two general categories of *flexing members* and *articulated joints*.

Flexing Members

This general category includes a rather wide variety of designs which may be further subdivided as follows:

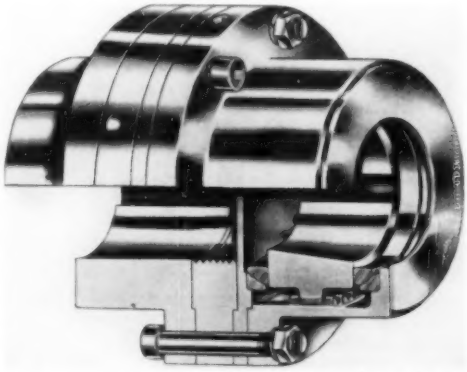
Quill Shaft. This type consists of a metal shaft having suitable cross-section and length in correct proportions and made of sufficiently flexible metal to permit a certain amount of flexibility. Depending upon its length and amount of flexing required, it may have one or more support bearings in its central portion. The Pontiac Tempest's "rope drive" propeller shaft is a popular example.

Metal Disk. This type generally consists of one or more thin flexible sheet metal disks connected between suitably designed metal connecting end plates.

Non-Metallic Disk. This type uses one or more non-metallic flexible disks fastened to suitably designed metal connecting ends or "spiders." Various kinds of rubber, plastic or impregnated fabrics may be used in the disks which may be made in various shapes.

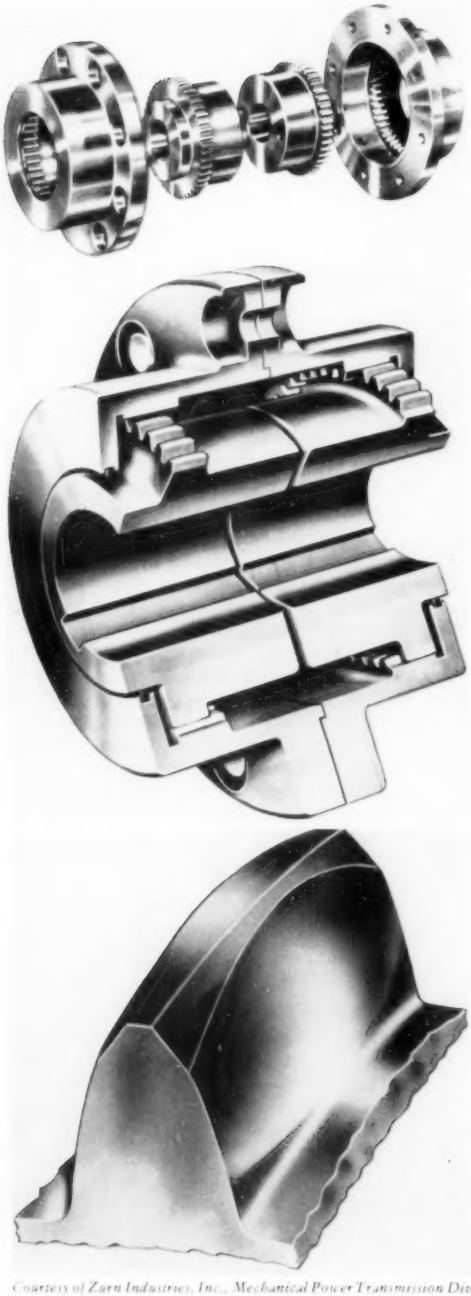
Flexible Cable. This type may be made of suitable woven or twisted metal wire or certain types of plastic connected to suitable end adapters. The speedometer drive cable in an automobile is a common example.

Spring Type. This type consists of metal springs between metal spiders or other projections on



Courtesy of Koppers Co., Inc.

Figure 2 — Single engagement gear coupling with spherical positioning rings.



Courtesy of Zurn Industries, Inc., Mechanical Power Transmission Div.

Figure 3 — "American Flexible" crowned tooth gear coupling showing an exploded assembly, a cross section and an enlargement of a crowned tooth.

end adapters. Some couplings of this type require lubrication which will be discussed later.

Non-Metallic Resilient Separating Member. The numerous examples of this group vary between a simple rubber or plastic tube bonded to metal end connecte , and rubber, plastic or other resilient material used in separators between the spiders or pins on suitably designed metal end adapting plates.

In general, flexing member couplings are designed for much lower loads than the articulated joint type, and usually do not require lubrication.

Articulated Joints

An articulated joint is made of rigid members and derives its flexibility from relative movement between the contacting parts, consequently it generally requires lubrication. The lubricant serves several important functions, probably the most important being to keep the moving contacting elements in the coupling as free from friction as possible, and thus maintain flexibility. Minimum friction also means least wear, and longer coupling life.

Since perfect alignment is practically never attained in practice, although theoretically possible, overheating is a possibility and therefore must be given consideration. Because of friction any coupling that is even slightly misaligned will develop heat which is equivalent to the power absorbed in overcoming the misalignment. The amount of heat developed will be dependent upon the design of the coupling, the amount of misalignment, the amount of load being transmitted, the coefficient of friction and the speed. The coefficient of friction for gear type couplings[4] is generally in the range of 0.1 to 0.3.

The heat generated in a coupling can be removed by convection, radiation and conduction from the coupling components themselves and by the circulation of lubricant, which in this case, also serves as a coolant.

Actually, the lubricant and lubricant circulation are the only factors that can be changed to reduce the final operating temperature of a coupling operating at high misalignment and high speed without making mechanical changes. This is of particular importance in high speed applications, such as steam and gas turbine installations.

In addition to friction and heat reduction, the lubricant also serves to prevent rusting under conditions of high humidity. In certain coupling designs and installations it helps to exclude foreign

Courtesy of Link-Belt Co.

Figure 4 — A gear coupling with straight-sided teeth. Note easily-removable pressed steel cover, rubber O-ring seals and plastic coated felt hub seal.

material which would cause severe wear or corrosion.

Thus, effective lubrication is a prime prerequisite in any type of lubricated coupling. The useful life of such a coupling is virtually contingent upon the use of a suitable lubricant and the extent to which it is retained in the coupling. Just as the coupling is a very small part of the over-all cost of a machine, so is the cost of the lubricant required a very small part of the initial cost of the coupling. Although the flexible coupling represents only a small fraction of the total cost of the power operated equipment to which it is attached, it is a very important fraction since the reliability of the equipment is only as good as the reliability of the connecting flexible coupling. Loss due to equipment down time is generally many times the cost of the coupling and almost infinitely greater than the cost of a lubricant that would have preserved it.

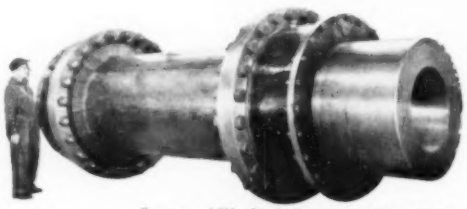
When preparing to select a coupling for a particular installation at least the following factors must be considered: average load; peak loading caused by pulsations and torsional vibration from either the driving or the driven machine; maximum speed; dynamic balance; maximum parallel and angular misalignments; maximum axial end play; possible exposure to moisture, dust, or corrosive chemicals; maximum and minimum operating temperatures; lubrication requirements, and frequency; physical dimensions such as shaft diameters, key way measurements, maximum length and diameter available for a coupling. Since precise evaluations of many of these factors and the design of a suitable coupling are complex and interdependent, the coupling manufacturers should be consulted.

GEAR COUPLINGS

The first gear type coupling, developed by Gustav Fast about 1918, was made with gears having the normal straight tooth form which is still widely used. The coupling was designed to accommodate an angular misalignment between connected shafts and transmit torque with practically uniform angular motion from the driving to the driven shaft without otherwise imparting or transmitting undue stresses or motions. These couplings were normally designed to allow mechanical, angular misalignment of ½ degree per gear set. The amount of parallel misalignment will vary depending upon the size of the coupling, axial separation of gear teeth and the clearance between the teeth.[4]

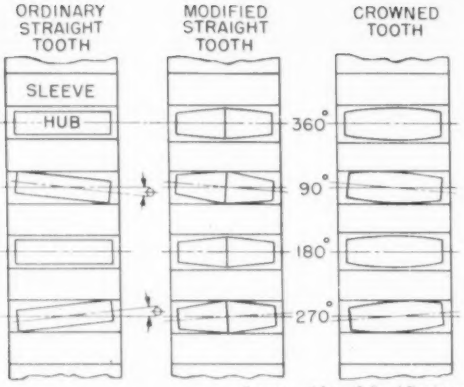
The gear type coupling in its simplest and probably most common form consists of two identical hubs with external gear teeth and a covering sleeve or shell-type member having internal gear teeth machined in it which mesh with the teeth on the hubs. The working action of such a coupling is that of a spline rather than gears since there is no relative *rotary* movement between internal and external gear teeth and they rotate together.[5] The sleeve may be a single piece but more commonly consists of two halves bolted together to facilitate installation. The typical general purpose gear coupling, illustrated in Figure 1, is more accurately referred to as a *double engagement* gear coupling and probably is the most widely used. The *single engagement* gear coupling illustrated in Figure 2 and consisting of only one hub in a sleeve with internal gear teeth, or essentially one-half of the double engagement type, is used in certain special applications.

Although the gear couplings manufactured today are very similar in basic design and operating principal to the original gear coupling developed over 40 years ago, a great deal of research and develop-



Courtesy of The Poole Foundry and Machine Co.

Figure 5 — A very large spacer-type coupling for a steel rolling mill. Coupling weighs 30 tons and transmits 3500 HP at 19.3 RPM.



Courtesy of Iron & Steel Engineer

Figure 6 — Full cycle misalignment patterns for different types of gear teeth.

ment has been done, especially in recent years. This development work has centered primarily around detailed modifications of the gear teeth and numerous variations in the specific arrangements and configurations of the coupling components to meet the special requirements of various installations and operating conditions. Figures 3, 4, 5 and 32 illustrate several typical gear couplings that vary somewhat in design and construction details. In addition, extensive work has been conducted on metallurgic and surface conditioning techniques of the running parts to improve their ability to carry greater loads at higher speeds and increase their expected service life. Also various improvements have been made in seals to prevent lubricant leakage and reduce entrance of harmful extraneous materials. As a result, the gear coupling is probably more widely used and considered to have greater flexibility than most other types of heavy duty flexible couplings.

When gear type couplings were first introduced, they were used primarily on heavy, relatively low speed equipment which was not too critical from an operation standpoint. With the increased tempo in industrial production there has been a continuously increasing demand for higher speeds, loads and greater flexibility in the flexible couplings. These demands have led to various modifications of the gear type coupling.

There are still many applications where the flexible coupling is expected only to compensate for the small amount of misalignment either angular or parallel or a combination of both due to unavoidable errors for which the standard straight tooth coupling is the simplest and most satisfactory. However, as gear coupling manufacturers have endeavored to extend the usefulness of this type of coupling to applications requiring much greater misalignment, various modifications of the straight sided tooth have evolved.[5] As might be expected, there is some difference of opinion among the various manufacturers as to the best tooth shape for a given application.

As mentioned earlier, it is generally considered that the straight sided tooth gear coupling will work very satisfactorily with an angular misalignment of ½ degree per gear set. However, with certain modified tooth configurations satisfactory operation is claimed for misalignment up to 6 degrees per half coupling.[6] In these cases, the need for adequate lubrication is stressed and will be discussed in more detail later.

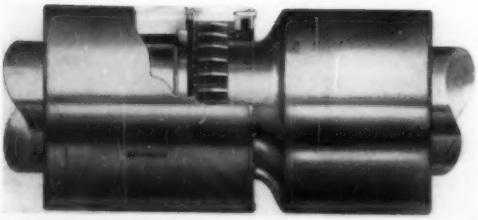
Under conditions of perfect alignment, all teeth in the gear coupling are in contact and the load is divided very nearly equally among all teeth. Unfortunately, the condition of perfect alignment is practically impossible to attain and consequently only part of the teeth carry the entire load transmitted by the coupling. In general, the greater the degree of misalignment the fewer the number of teeth in contact to carry the load and thus the greater the unit loading per tooth. Figure 6 illustrates the full-cycle misalignment effect on a straight gear tooth, modified straight tooth and crowned tooth,[6] that of the straight tooth, being exaggerated by using much more than the normal half-degree of misalignment.

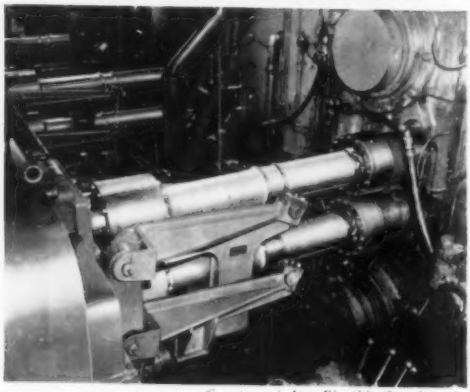
To offset the increase in unit loading, it is necessary either to increase the physical size of the coupling or to further improve the load carrying ability of the teeth. Since there are many applications where available space limits the size of the coupling, considerable development work has been done by various coupling manufacturers to increase the load carrying ability of the coupling gear teeth by improved metallurgy and by surface hardening. The specific methods or techniques used, vary with the individual manufacturers and are generally patent-protected or "company confidential" features which can not be discussed further.

Many of the features designed into the gear type coupling, over the years, have evolved primarily as a result of the great demand of the steel industry. Drives in the steel industry are typified by, but not necessarily restricted to, high torque, low speed applications with ruggedness and reliability being additional distinguishing characteristics.[4] In view of their generally reliable service over many years

Courtesy of Iron & Steel Engineer

Figure 7 — Schematic diagram of a spindle type coupling illustrating how separation of the two gear sets with a spindle increases the coupling's off-set capacity.





Courtesy of Ajax Flexible Coupling Co.

Figure 8 — (Upper) One end of a dihedral tooth type spindle coupling with synthetic rubber lip type seal. (Lower) Typical rolling mill installations.

under these very severe operating conditions, the gear type coupling has gained the reputation of being the "work-horse" of the steel industry; however they are also used extensively and satisfactorily in many other industries under a wide variety of operating conditions.

One of the most recent innovations in gear couplings is the so-called *spindle type*[3] which was developed to meet the requirement for a flxible coupling which would operate under conditions of much greater misaligment while retaining other features of the gear type coupling such as ruggedness and high load carrying ability. As illustrated schematically in Figure 7 the spindle type coupling consists essentially of two single engagement gear type couplings connected with a spacer or floating shaft. As is evident from this diagram, the long spacer provides greater compensation for misalignment but also requires more space. Typical spindle type gear couplings and installations are shown in Figures 8 and 9.

In general, the spindle type coupling presents more operating problems since the normal problems for standard gear couplings as well as its own additional ones usually are present.[4] Generally included in the additional problems are the effects of:

1. Large and variable amounts of misalignment.
2. Space limitations.
3. Shock loading and high torque.
4. Need for quick change or disassembly features.
5. Special features such as overloading protection and long axial movement.

Since all of these tend to give more severe operating conditions, complete lubrication at all times is essential: even momentary operation without a lubricant or with an inadequate lubricant can easily lead to complete and early failure of a spindle type coupling.

Gear Coupling Lubrication

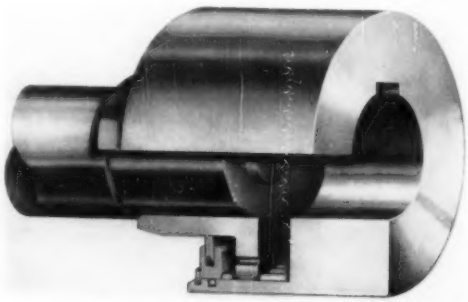
The successful operation of a gear type coupling is predicated on positive lubrication which assures the constant presence of an adequate film of lubricant between its gear teeth. Either oil or grease is used and the choice generally depends on the specific design of the gear coupling and the operating conditions under which it is used. Neither is best for all operating conditions or installations and methods of application differ.

Grease Lubrication

For many years oil was used almost exclusively for lubrication of gear type couplings. However, in recent years the trend has been toward the use of grease for most normal gear coupling installations. This trend is attributed to improvements made in greases and coupling design.

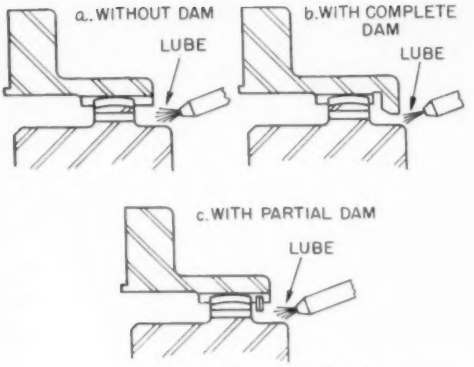
It is common practice when assembling or installing grease-lubricated couplings to apply a sufficient quantity of grease to the gear teeth to insure a good initial coating on all working parts when it first goes into operation. To facilitate relubrication, such couplings are generally provided with two plugs at diametrically opposite positions in the coupling sleeve or housing. By removing these plugs and attaching a pressure gun to one opening, grease can be forced through the coupling to assure adequate lubricant and provide for as much flushing as the particular conditions may require.

While the proper selection of a grease will depend on the specific conditions of operation, a suit-



Courtesy of Koppers Co., Inc.

Figure 9 — A crowned tooth spindle coupling with conformable metallic piston ring seal.



Courtesy of Iron & Steel Engineer

Figure 10 — Schematic sketch showing types of oil dams used in continuously lubricated gear couplings.

able grease for widely varying operating conditions may be described as having the following general characteristics:

1. Adhesiveness to assure good retention of the grease on the coupling moving parts.
2. Resistance to excessive oil separation.
3. Good high temperature properties including oxidation resistance.
4. Good lubrication at the lowest operating temperature to be encountered.
5. Adequate extreme pressure (EP) and anti-wear properties. These characteristics may not be necessary in standard couplings under minimum misalignment but are particularly desirable for high misalignment and axial movement under high loads.

Oil Lubrication

In spite of the trend towards grease lubrication there are certain coupling installations where oil lubrication is preferable because of:

1. Lack of accessibility. Relubrication with grease is either very difficult or impractical because of continuous coupling operation.
2. Common lubricant. Couplings are enclosed in part of the machine and thus lubricated by the oil used for the lubrication of other machine parts.
3. Very high speeds. Greases may separate under these conditions, might also cause unbalance of the coupling.
4. Very low temperatures. Under such conditions a grease might cause too much resistance to the moving parts in the coupling and its resistance to flow could contribute to unbalance, thus an oil of suitable viscosity would be preferred.
5. Very high temperatures. With suitable coupling design fresh oil can be continuously supplied to cool the coupling and reduce oil oxidation.

Method of Oil Lubrication

When oil is used for lubrication of gear type couplings, there are three possible methods of applying it, as follows.[6]

(a) Single-charge. In this method sufficient oil is placed in the coupling so that at running conditions the radial depth of the layer of oil thrown out against the sleeve is more than the height of the sleeve teeth but less than the height of any retention device. Figure 1 illustrates depths of the oil under both running and standing conditions.

(b) Intermittent. In this method the coupling is initially filled to the proper level, then oil is supplied periodically (either automatically or manually) to maintain an adequate quantity.

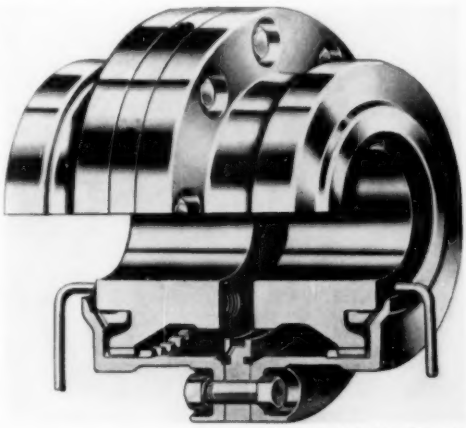
(c) Continuous. To permit continuous oil circulation and as schematically portrayed in Figure 10, the coupling may be designed without any dam, with a complete dam, or with a partial dam. Figures 11 and 12 illustrate two continuously-lubricated couplings, the latter being a spacer type.

Since any solid extraneous materials will be centrifuged into the coupling teeth to cause binding, deposits and wear, all oil-lubricated gear couplings must be provided with clean oil. Both continuously and intermittently lubricated couplings are usually supplied through an oil filter.

Oil Type

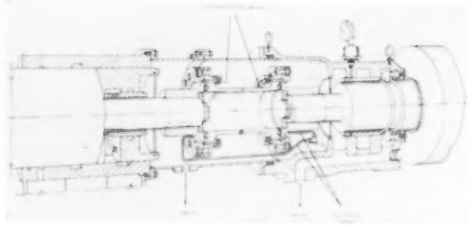
Depending upon the temperatures of operation, the size of the coupling and other conditions, either a straight mineral oil or an additive type gear lubricant may be used.

Very cold operating conditions may require an oil having a viscosity as low as 100 Saybolt Universal Seconds (SUS) at 210° F, or even lower. Con-



Courtesy of Koppers Co., Inc.

Figure 11 — A continuously lubricated gear coupling.



Courtesy of DeLaval Steam Turbine Co.

Figure 12 — A continuously lubricated spacer type gear coupling driven by a steam turbine.

versely, under high temperature operating conditions, such as in certain steel or cement mill operations, an oil with a viscosity as high as 1000 SUS at 210° F, would be preferable.

FLEXIBLE CHAIN COUPLINGS

The chain type flexible coupling can be described as consisting essentially of two identical sprockets with suitable shaft hubs and a single chain to connect the two sprockets.

Chain type flexible couplings are manufactured by most chain drive manufacturers. In some instances, the standard chain and sprocket used for chain drives are also used for flexible couplings. In others the sprocket and chain link design are changed somewhat to make them more adaptable for the purpose of flexible couplings.

Although the basic design and operating principle of all flexible chain type couplings are similar they vary somewhat in:[7]

1. The specific design and shape of the sprocket teeth.
2. The type of chain link used.

Generally speaking, both the chain and the sprockets are made of steel. There are, of course, variations in the metallurgy depending upon the manufacturers. For some special applications, the chains are made of a plastic such as nylon which requires no lubrication. However, the load capacity for such material is much lower than for the same size all steel coupling.

There are several different types of chain links used in flexible couplings. The main ones are as follows:

1. Single strand roller chain with:
   (a) Single roller
   (b) With a double roller—(See Figure 13)
2. Double strand chain—(See Figure 14)
   (a) 2 cylindrical rollers.
   (b) 1 cylindrical, 1 spherical roller.
3. Silent chain—(See Figure 15)

When a silent chain is being used for making a flexible coupling, it is necessary to provide it with guide links of some type which fit into a groove in one sprocket or between the two sprockets to prevent the chain from moving axially and off the two connected sprockets.

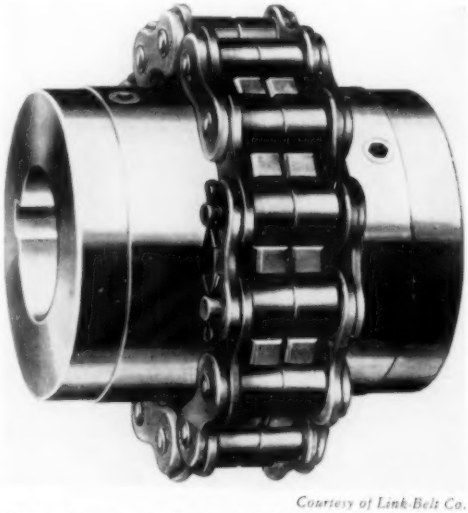
One of the main features of the chain type flexible coupling is its simplicity of design and installation. It is also generally considered to require minimum space for the amount of load that can be transmitted. This is in part at least due to the fact that under conditions of minimum misalignment which is the condition for which it is generally used, the load is divided quite equally among most of the teeth on the sprocket. Since there are many contact points between the chain links and sprocket teeth, the load to be carried is distributed so that unit stresses are very small.[7]

Flexibility in chain type couplings is developed due to the freedom of motion between the sprocket teeth and the chain and also due to built-in clearances between the rollers, bushings, pins and link plates in the case of roller type chain as illustrated in Figure 16.

For installation where more than the normal amount of angular and parallel misalignment must be compensated for a compound double chain coupling separated by as long a segment of shaft as the installation permits may be used. An example of this is shown in Figure 17.

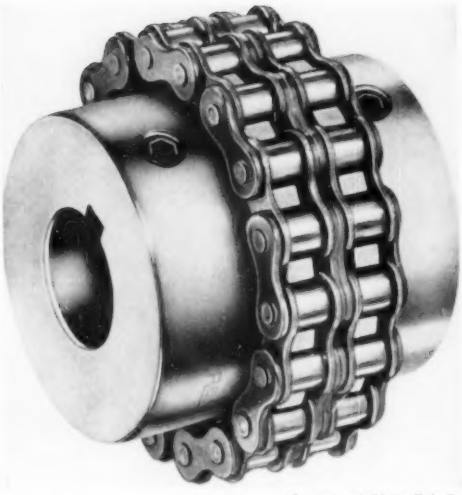
Advantages of Housing

Chain type flexible couplings can be operated with or without a protective cover or housing; however the use of a cover like those shown in Figures 15 and 18 is strongly recommended and has increased in recent years. The protective housing or cover is most advantageous for couplings that are



Courtesy of Link-Belt Co.

Figure 13 — A single-strand divided-roller chain type coupling.



Courtesy of Chain Belt Co.

Figure 14 — A double strand cylindrical roller chain type coupling.

operated at moderate to high speeds or subjected to abrasive materials, moisture or corrosive chemical materials.

For most normal installations, covers may be made of cast, formed, spun or welded metal, either ferrous or a light metal like aluminum. When couplings are exposed to corrosive chemicals, however, special covers made from stainless steel, plastic or other corrosion resistant materials should be used. Similarly the gaskets and seals for such covers are made from such chemically resistant materials as chloroprene and other synthetic rubbers or elastomers. When speeds go up so that lubricant retention becomes a problem due to centrifugal force, covers are very definitely desirable and prolong the life of the coupling. When couplings are operated inside equipment housings where they are automatically lubricated by lubricants used for other parts in the equipment, covers are not necessary.

Lubrication

Grease is the preferred lubricant for chain type flexible couplings. When assembling a chain coupling it is normal practice to place a sufficient quantity of a Number 1 ball and roller bearing grease on the sprocket teeth and chains so that when the cover is installed and tightened a small amount of grease will be forced out at the gasket and seal areas.

In some instances, the covers are equipped with a suitable fitting so that grease can be forced into and through the coupling at regular intervals depending upon the type of service and operating conditions. Although desirable from the standpoint of assuring a plentiful supply of lubricant around the working parts, such overfilling does have the disadvantage of causing leakage.

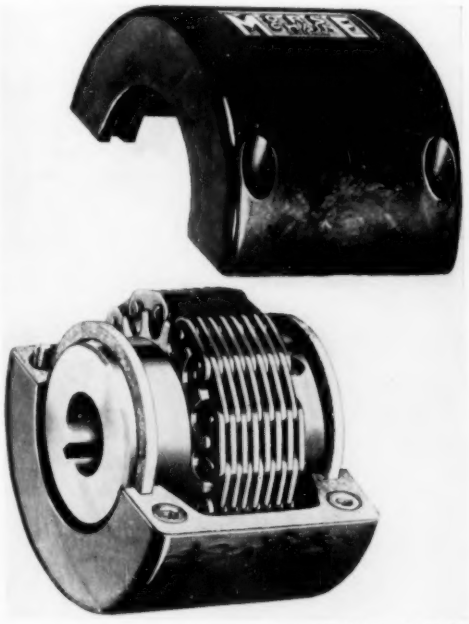
UNIVERSAL SPINDLE COUPLING

As the name implies, the universal spindle coupling operates as a universal joint and accordingly is used primarily where very high degrees of misalignment are required. This type of coupling is used extensively in steel mill operations to connect the mill pinions to rolls of slabbing mills, edging mills and other similar type rolling mill equipment. It also would be used for similar types of equipment in other industries.

Figure 19 illustrates a typical universal spindle coupling. It consists of a steel jaw-half (left) which includes the bearing segment assembly consisting of two bronze "slippers" on the bearing pin. The steel blade-half is indicated on the right. Such a universal joint is located on each end of a spindle thus increasing the amount of parallel misalignment that is necessary and caused by roll adjustments under which the coupling can operate satisfactorily.

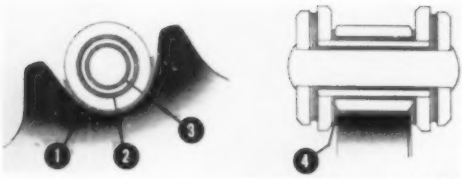
Lubrication

The lubrication of the bronze slippers in these couplings presents a difficult problem because of the centrifugal force causing the lubricant to be thrown off and because those equipped with grease fittings



Courtesy of Morse Chain Co.

Figure 15 — A silent chain type coupling with plastic cover showing gaskets and seals.



Courtesy of Diamond Chain Co.

Figure 16 — Built-in clearances between (1) chain rollers and sprocket teeth, (2) chain rollers and bushings, (3) bushings and pins and (4) link plates and sprocket teeth.

cannot be lubricated at frequent enough intervals without causing loss of production. In addition, this type of coupling is difficult to protect from exposure to abrasive type foreign contaminants that are generally present in the areas surrounding conditions under which they are used. For example in steel mill applications the joints are subjected not only to dirt but to scale, water and high temperatures. It is evident that under such severe operating conditions frequent lubrication is imperative.

The lubrication problem has been approached from several angles with varying degrees of success. Although none have been entirely satisfactory, bronze slipper life has been extended by the use of the following methods:[8,9]

1. Lubricant supplied to the slipper surfaces either continuously or automatically, or both. A number of devices or methods have been designed for this specific purpose. These include:
   (a) Drilled shaft method with lubricant supplied under pressure through a hole drilled through the center of the shaft.
   (b) An enclosed oil spray. In this method, oil is aimed at the bearing segment being either dripped or sprayed through the upper section of the joint. The excess oil is returned to the circulating system.
   (c) Stationary collars. In this system, various types of slip collar arrangements have been used to transmit grease from the mill supply to the coupling head rotating within the collar.
2. Application of a very adhesive EP type grease at every opportunity available.
3. Wrapping the coupling with canvas or heavy water-proof paper to retard the throw-off of grease.
4. A fairly effective method has been used in some installations where lead napthenate type EP gear lubricant (750 SUS at 210° F) is sprayed for one minute out of every half hour on the coupling while in motion.

SLIDER TYPE COUPLINGS

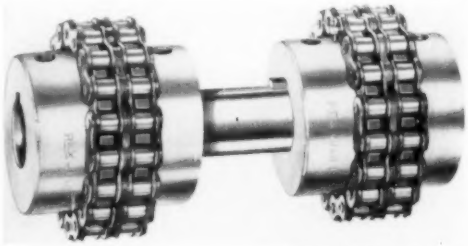
This type of coupling consists of two forged steel or cast alloy flanged hubs connected by a square slider member. Each flange has two projecting "C" shaped jaws which engage opposite sides of the slider permitting relative sliding motion of the two flanges at right angles to each other. Heavy duty sliders are either self-lubricating metal blocks with loosely attached replaceable bearing surfaces or oil-impregnated sintered metal. Although the floating center member is generally a one-piece element, it is possible to add bearing strips to each side as an aid to lubrication. These replaceable strips can be made of softer metal than steel if desired depending upon the extent of the load to be transmitted and the degree of misalignment encountered in operation. For light duty service, sliders may be made of a laminated plastic material which does not require lubrication. A typical slider type coupling is illustrated in Figure 20.

In another version of the slider type coupling, the center portion consists of a disk with tongue projections across each face and placed 90 degrees from each other to engage mating slots on the face of each end hub.

Since parallel or angular misalignment between shafts or shaft axial movement in this type coupling causes relative movement between the floating center member and the contacting surfaces of the end plates, it requires lubrication. Oil or grease may be used to lubricate the floating center member along its sides contacting the jaws of the end flanges. In one type of design a self-contained lubricant reservoir is incorporated. In this type, the reservoir may be refilled periodically with lubricant by removing the bearing strips, refilling and replacing without disturbing the other coupling elements. In another design where grease lubrication is required, the floating member has a hollow center which the manufacturers recommend should be filled half-full with a high grade medium consistency grease in the NLGI No. 2 range. In both the oil or grease lubricated coupling of this type, lubricant can be renewed through holes in the flanges or via a pressure gun fitting.

FLOATING KEY TYPE

The floating steel key type coupling is another rigid component all-metal lubricated type coupling. One design of this type is comprised of two steel



Courtesy of Chain Belt Co.

Figure 17 — Compound double-strand roller chain couplings with spindle shaft to permit greater misalignment.

Courtesy of Diamond Chain Co.

Figure 18 — Double-strand roller chain coupling with grease tight metal cover.

hubs each keyed to its respective shaft. On each hub dovetail slots are cut wherein the steel keys are located in the final assembly. These keys are free to float on a film of oil which is maintained by centrifugal force by the rotation of the coupling. In some instances, the keys are drilled to afford greater oil carrying capacity to give more positive assurance of adequate lubrication.

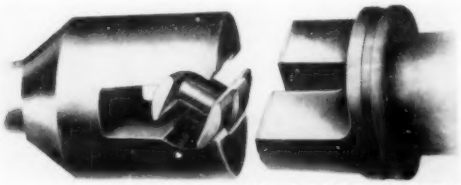
The number of keys used in this type coupling depend upon its size. In the smaller types, three keys are installed whereas in larger couplings five keys may be used. The general construction of this type coupling in all sizes is such as to prevent entry of dust or dirt and enable oil retention with a minimum of leakage.

Lubrication

Key type couplings are normally designed for oil lubrication. Oil circulation to and around the keys is assisted by centrifugal force, the pressure developed in normal operation being sufficient to keep the clearance spaces between the keys and their respective slots completely filled with oil. This tends to minimize the possibility of metal-to-metal contact even under extreme conditions of misalignment.

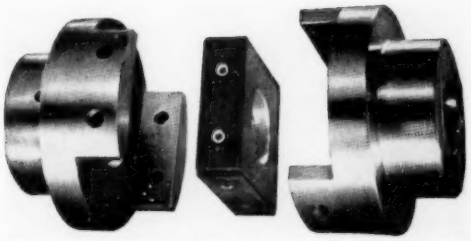
Adequate oil distribution often facilitates more complete freedom of rocking action of the respective keys thereby preventing localized wear. The noiseless operation of this type coupling is an indication of effective lubrication. In normal operation this coupling requires the use of a medium viscosity highly refined straight mineral oil with a viscosity of from 300 to 600 SUS at 100° F. For low temperature operation, oil with a viscosity in a lower range and a suitably low pour point should be used.

A lip at one side of the casing of this type coupling is provided for application of oil. Relubrication normally should be carried out when the coupling is at rest, filling to the level of the lip. Such couplings should be drained, cleaned and filled with fresh oil about once a year.



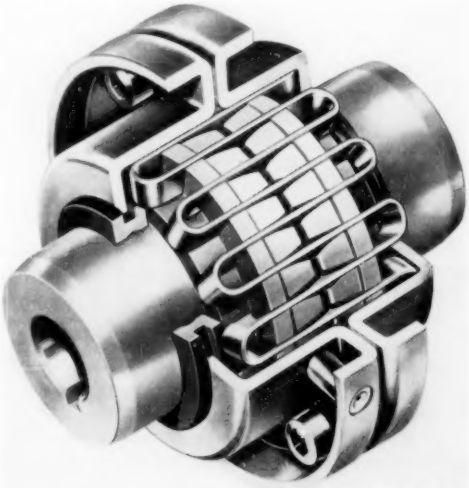
Courtesy of Mesta Machine Co.

Figure 19 — A universal type spindle coupling.



Courtesy of Zurn Industries, Inc., Mechanical Power Transmission Div.

Figure 20 — A slider type flexible coupling with self-lubricating central member.



Courtesy of The Falk Corp.

Figure 21 — A "steelflex" coupling. Note flexible steel member, synthetic rubber seal and lubrication fitting.

LUBRICATED FLEXING MEMBER COUPLINGS

There are several types of couplings that derive their flexibility from both the flexing of one of its components and the relative movement between metal parts and, therefore, require lubrication. One of the main features emphasized for this type coupling is its ability to absorb and minimize shock loading and vibration.

Steel Pin Type

There are several couplings using a laminated steel pin as the flexible medium in the coupling. In one such design, the hub carries radial laminated springs as spokes which engage mating internal slots in a drive ring mounted to the flange of the companion hub. In another design, the laminated steel pins are inserted in bronze, graphited or oilless type bronze wax impregnated bushings. These laminated steel springs are locked in place with a spring retaining ring in one of the flanges and mounted in the bronze inserts in the flange which is opposed to the one in which the steel retaining spring is located. A further modification of the latter type consists of two sets of such pins with a floating ring retainer for each set. This is referred to also as a double floating ring type of coupling. By using a double set of pins, the coupling is adaptable to more severe operation and is capable of carrying greater loads.

All designs of this type of coupling require lubrication. For average coupling installations, a medium viscosity highly refined oil has been found to be satisfactory. The oil case should be filled until the level is nearly up to the lower rim of the coupling. Renewal of oil is advisable at regular intervals to maintain the level in the case at the proper height. Where service may be very severe, continuous oil lubrication is recommended by the manufacturers. To facilitate the continuous lubrication, the coupling is enclosed in a suitable oil retaining case.

For some applications, depending upon the operating conditions, grease may be preferable as the lubricant. Accordingly, these couplings are designed with a seal suitable for retaining grease or oil.

Steel Grid or Spring Type

As illustrated in Figure 21 couplings of this double engagement type derive their flexibility from the action of forged alloy steel grids on curved toothed steel hubs. The grid fits snugly in the grooves with sufficient clearance to provide for a rocking and sliding action to accommodate parallel and angular shaft misalignment and end float.

The cross section of the grid and radius of the slots are designed to maintain a constant stress on the grid as it bends and wraps around the tooth as required to smooth out variations of torque load. The torsional cushion thus provided minimizes the adverse effect of shock and vibration on the alignment of the connected machines.

Grease Lubrication Prevails

Grease lubrication is essential to free action of the parts in steel grid couplings. The lubricant is contained by a two-piece steel cover with a gasket between the halves and neoprene seals at the hubs. When assembling the coupling, grease is packed into the spaces between and around the grids. For proper lubrication, the coupling should be completely packed with lubricant, so that air pockets will be eliminated and a reservoir of grease provided in the space between the hubs. The action of centrifugal force on the grease will fill any small air pockets which may remain around the grid member after assembly. In normal operation, a grid or spring type coupling should be lubricated annually by means of a pressure gun. In relubricating, the coupling should be vented by prying up the ring seal with a nail or small screw driver. The neoprene seals and fibre gasket prevent loss of lubricant and entrance of water, dust, or other foreign material.

Greases of the "all-purpose" or "multi-purpose" types recommended for general industrial use in ball and roller bearings have proven entirely satisfactory in grid type couplings. The action of the grid-groove design is such that heat developed under misalignment is insufficient to adversely affect the stability of these greases and only ambient temperatures need be considered. Generally speaking, the grease used to successfully lubricate the bearings on the connected shafts will be entirely satisfactory.

The concluding portion of this article will appear in the November 1961 issue of this publication.

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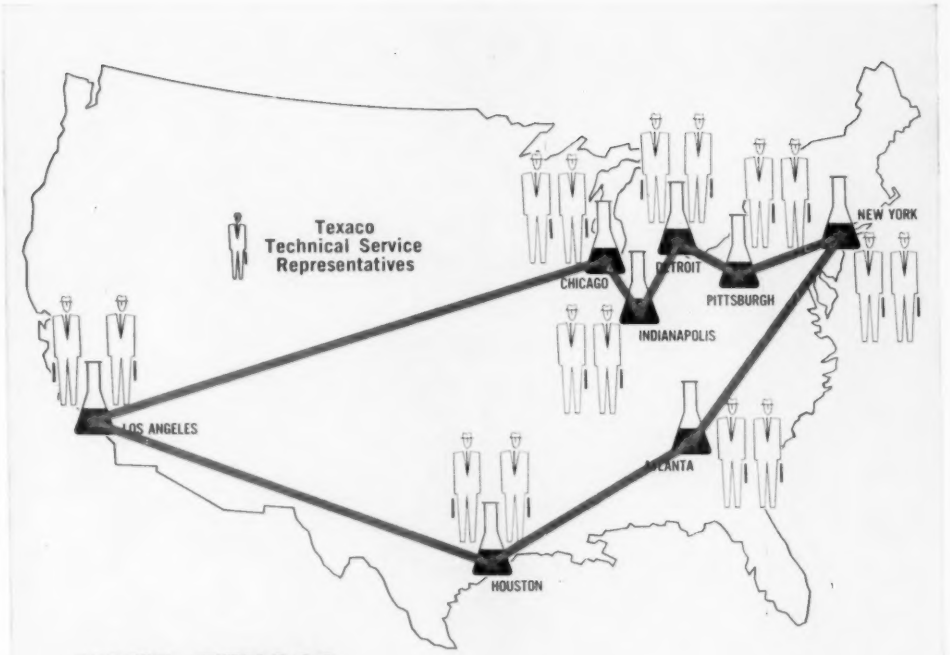

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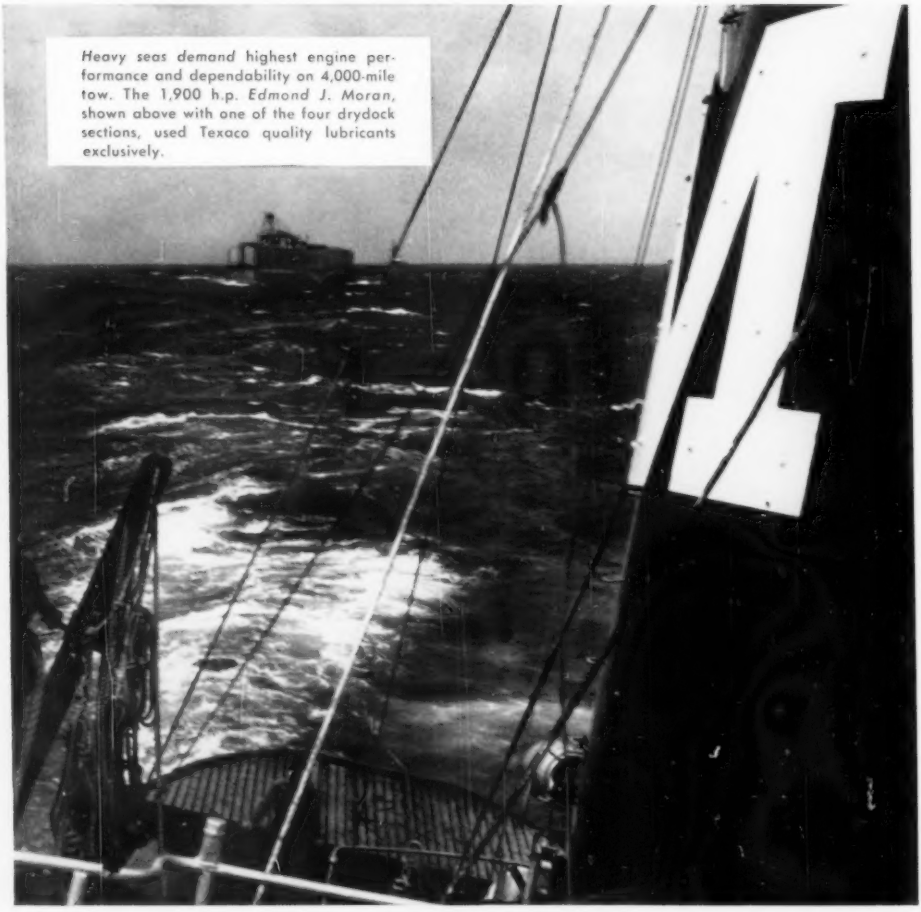

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